ART. VII.—*Experiments to prove the Existence of a Peculiar Physico-organic Action, inherent in Animal Tissues, called Endosmose and Exosmose.** By JOSEPH TOGNO, M. D.

THE following experiments were suggested by the perusal of Dr. DUTROCHET's interesting memoir "On the Intimate Structure of Animals and Vegetables, and on their Motility," and especially by the chapter entitled "Observations and Experiments on the *Turgid State.*" The actions of endosmose and exosmose seemed to throw so much light upon the process of absorption and secretion, especially the exhalation of fluids into cavities constituting dropsy, that I felt desirous of repeating the experiments of Dr. Dutrochet, and of extending them to the membranes which are the seat of dropsy.

Absorption is generally divided into *external* and *internal.*

The former, according to CRUICKSHANKS, HEWSON, HEDWIG, &c. is performed by a set of vessels arising immediately from the free surface of the digestive mucous membrane, the orifices of which they assert having distinctly observed; whilst equally good authorities, as RUDOLPHI, MECKEL, CUVIER, and others, affirm that they originate from the soft and spongy substance which covers the interior of this mucous membrane, and which is capable of *imbibition.*

Of the formation of the orifices of the chyliferous vessels we are at present ignorant, as well as in what the action of absorption consists. We know, however, these vessels must possess "*a peculiar action,*" by virtue of which they take from the chyme the elements needful for the formation of a new fluid, *chyle;* but in what this "*peculiar action*" consists no physiologist has ever been able to explain satisfactorily. It has been ascribed by some to the compression of the intestinal parietes, which, by mechanical pressure, forces the chyle into the *gaping orifices* of the chyliferous vessels; by others to the capillary attraction of the mouths of these vessels; again, by others, to a special sensibility together with an organic contractility of the absorbing *orifices,* &c. A very curious circumstance, worthy of being noticed in this place, and which was first observed by MAGENDIE, is that this absorption continues for some time after death, showing that the action of absorption does not entirely depend upon the laws of vitality, but on a physical action independent, to a certain degree, of vitality.

Recently, Messrs. RIBES and MAGENDIE have revived the opinion

* *Endosmose,* an impulsion or action inwardly, from ἔνδον, inward; and ὠσμός, impulse; and exosmose, the reverse action, from ἔξω, out; and ὠσμός, impulse.

of the ancients, that liquids are absorbed by the mesenteric veins, but in what manner, they have never pretended to explain.

These considerations on external absorption leave room to suppose that there is yet some mysterious action in this function, of which we are entirely ignorant.

We are still less acquainted with internal absorption; the greatest obscurity existing as well in reference to its phenomena as to its mechanism.*

The lymphatics are distributed into two sets in almost every organ, the one superficial, the other deep-seated. Their mode of origin is unknown. Some anatomists admit between these vessels and the arteries a direct communication; others think that they open by a gaping orifice on the surfaces and into the structure of the organs. Lieberkuhn asserts that at their extremity is to be observed a *small spongy vesicle*, in which terminates an artery and a vein. This observation seems to coincide with the mode of termination of the mucous membrane of the lungs, which terminates in small cells resembling a bunch of grapes, and the same structure is to be observed in the formation of the salivary glands, the liver, the pancreas, and follicles which are disseminated all over this mucous membrane, they being mere prolongations of this membrane, and all terminating in an infinite number of cul-de-sacs, the parietes of which are irrigated by very minute blood-vessels. It is in these cul-de-sacs that all secretions are produced. This structure of all secreting organs is particularly worthy of our attention; for we shall find it to be a very important clew to the discovery of the mode of function of all secretory organs, especially when we shall apply the principles to be deduced from the following experiments.

The lymphatic ganglia are considered by Haller, Albinus, Hewson, Meckel, &c. as being clusters of lymphatic vessels; Malpighi, Nuck, Hunter, and Cruickshanks assert that these are here interrupted by *small cells.*

With respect to the mechanism of this function, M. Hutin, in his Manual of Physiology, says, "The mechanism of this function is rather inferred by the observation of its result, than by any positive knowledge we have of it; this function indeed is in itself inscrutable, so that we can only offer conjectures respecting it."

All the hypotheses which have been imagined to account for the one, have also been applied to explain the other; but the only one in my estimation worthy of being referred to, is the passive imbibition by a kind of spongy substance, in which it is supposed these vessels arise, &c.

* See Hutin's Physiology, p. 61 to 70.

Malpighi considered the ganglia of these vessels to be so many little hearts, or active powers, placed at different distances along the course of these vessels, to excite the circulation of the lymph. They could possess this supposed power if they were hollow sacks, in which the action of endosmose and exosmose could take place, and then we might grant them this appellation of *little hearts.*

With respect to venous absorption, many physiologists deny to the veins this property, and consider them as only taking up, or rather receiving in a passive manner, the remainder of the arterial blood through an uninterrupted continuation of tubes. But an examination of the capillary circulation of a frog, through a microscope, has convinced me that the capillary circulation is not performed in continuous tubes, as generally believed, but in the meshes of the cellular structure, or parenchyma of the organs. Nevertheless, the experiments of Magendie establish beyond doubt venous absorption, and the manner in which he accounts for it, is that it occurs by a *capillary attraction;* but we are no wiser after this explanation. M. Fodera supposes this kind of action to be owing to a species of *imbibition* of the tissues, an idea which seems to me the most probable.

Recently Messrs. Ribes, and Leuret and Lassaigne, positively declare having perceived the free orifice of veins on the external surface of the intestines, and still more recently Messrs. Fohmann, Lauth, Jr. and Lippi have discovered numerous communications between the lymphatics and the veins, and by this communication they wish to account for the apparent absorbing power of these latter vessels. We shall only add to the various and very different observations already quoted, that Dr. Flandrin has observed absorption to occur through both the venous and lymphatic systems.*

In venous, as in lymphatic absorption, the difficulty consists in explaining satisfactorily its mechanism, because in both these systems the *absorbent action,* whatever it may be, must be the same, since the same end is attained in both, and both systems act on the same materials.

As closely connected with the subject, I must be permitted to offer a few cursory observations on the secretions.

Blumenbach ascribes the absolute cause of most secretions to the intimate *structure* of the secreting organs, and also to the parenchyma, which he thinks is possessed of a "*vita propria,*" "a peculiar species of vitality distinct from the *common vital powers* of contractility, irritability, and sensibility." This is to say what is not secretion, but does not explain either the *structure* of the secreting organ, or the action producing secretions; nor are we any wiser after this explanation.

* Journal des Progrès, Vol. VII.

The same may be said almost of all the explanations advanced by different writers; I therefore shall dwell but slightly on them, and proceed to expose some of the views suggested to me by Dr. Dutrochet.

The principal opinions entertained respecting this function may be divided into the *physical, chemical, and vital theories.*

1st. *Physical theories.*—Boerhaave, Malpighi, Haller, &c. were of opinion that all humours primitively existed in the blood, and that the vessels diminished gradually in fit proportions to the size of the globules of that fluid. These considerations led them to believe that all secretions were the result of *mechanical filtrations.* Other physiologists compare the secretory *vessels* to a roll of cotton, which, when plunged into a mixture, would only attract the fluid with which the cotton had been previously imbued. Dr. Fodera, from a series of experiments lately performed, was led to consider exhalation as a simple transudation, and absorption as an action of imbibition. He ascribes these two phenomena to the *capillarity* of the tissues, and asks if it were possible to extend this explanation to follicular and glandular secretions.

2d. *Chemical theories.*—The supposed *leaven* of some ancient physiologists is too absurd to require notice.

Berzelius, a great name in chemistry, explains secretions by an electric influence. Messrs. Prevost and Dumas assert that the secreted fluids are the product of a *galvanic power*, caused by the globules of the blood, which, according to them, represent or stand for so many galvanic plates in a state of action. In this respect the observations of Dr. Fodéra, who has remarked that a stream of electricity excited transudations, favours very much the position of these celebrated experimenters. Still I believe they have fallen into an error in ascribing to the globules of the blood what really belongs to the vesicles or globules of the tissues of the organs.

3d. *Vital theory.*—This theory originated with Stahl, and was supported by Bordeu, by Barthez and Bichat. It supposes in every secretory organ a kind of digestive action; but we are entirely unacquainted with this *peculiar organic* and *vital elaboration;* so that we are now just as far removed from a knowledge of the process as ever, and as ignorant of its nature.

A word now on Dr. Dutrochet's views on this subject before giving my experiments.

All the tissues or organs of animals are essentially composed of agglomerated, globular, or vesicular cells. This fact had been partially announced by Leuwenhoek, and not long ago confirmed by the repeated microscopical observations of one of the most accurate ob-

servers of our age, Dr. Milne Edwards. This great and luminous truth, that all tissues can be solved into globules, as an elementary form is so universal, and these elements or monads are every way so similar, that when observed with the microscope, it is difficult to discriminate parts of the brain from the liver or the tissue composing any other organ. This uniformity of elementary formation of the parenchyma of all the parts of organized bodies, proves that they differ only in the nature of the substances that the vesicular or globular cells contain, and of which the organs are entirely composed; and according to Dr. Dutrochet, it is in these cells or vesicles that secretions occur, and they furnish the fluid proper to each organ, which fluid is probably transmitted by transudation into the excretory canals. Thus we see that according to this author the vesicular structure is the *sine qua non* of all secretory actions. By this vesicular formation of the tissues of our organs, we possess the indispensable and fundamental condition for the production of endosmose and exosmose, into which all the vital actions are to be resolved.

It is well known also, that the fluids of the body are, like the solids, composed of globules, and hence they have in their intimate composition the elements of the solids, and may be considered also *organized*, without much violence to sound philosophy. The only difference is that in the former the globules are free and unconnected, whilst in the latter or the solids, they are adherent and agglomerated; so that the figurative appellation given to the blood by Dr. Broussais of "*chair coulante*," is no longer a metaphor, but a reality. Hence, if the blood of a person emaciated by sickness and abstinence be examined through the microscope, very few globules will be found; showing that they are always in the same proportion as the state of assimilation.

Experiments—First Series.

The intestines, cœca, and crops of two fowls killed the previous day, having been cleaned completely, the parts of the intestines being each five inches long, were selected for the following experiments.*

The substance experimented upon was gum arabic in solution, the proportions being gum arabic ℥j.—water ℥vi.

July 26th, 1828, 6 P. M.—Fahrenheit's thermometer ranged from 78° to 82°. —No. 1. Two of the cœca were less than one-half filled with gum arabic solution, and ligatures firmly applied.

* These experiments were performed in a cellar, the temperature above ground being too high.

No. 2. Two crops were also half filled with the same solution, and ligatures firmly applied to prevent any liquid from escaping or entering through their natural openings. Both No. 1 and 2, were plunged into a basin of fresh river water, and permitted to remain all night undisturbed.

No. 3. Two cœca, about four inches long, were filled with simple water, and a ligature firmly applied; they were then immersed in a solution of gum arabic.

No. 4. Three pieces of intestines, perfectly empty, were tied at their extremities, and immersed in water.

July 27th, 8 A. M.—Examined the preceding experiments, and found:—No. 1. The cœca were by this time full, indeed nearly *turgid*. This *endosmose* is even more active than that reported by Dr. Dutrochet. Being rather astonished at this "*turgid state*," I was induced to examine the ligatures as well as the cœca, fearful of being deceived, but found every part perfectly tight.

No. 2. The two crops were examined, and were nearly as turgid as the two cœca placed in the same basin. The water of this basin was renewed.

No. 3. The two cœca were perfectly empty of all their water.

No. 4. The intestines had already introduced a thimbleful of water.

The water in the vessel was renewed.

July 27th, 6 P. M.—Fahr. 80°.—No. 1. Renewed the water in the vessel. The cœca continue turgid.

No. 2. The crops are now very turgid; one, however, more than the other.

No. 3. Dismissed as very satisfactory, having produced a very perfect instance of exosmose.

No. 4. The intestines which were empty, are now more than one-third full. The water in the vessel again renewed.

July 28th, 5 P. M.—Fahr. 77°.—No. 1. The cœca less turgid.

No. 2. The crops as turgid as ever; indeed rather more so. Renewed the water in the vessel.

No. 4. Rather more turgid.

July 29th, 11 A. M.—Fahr. 74°.—No. 1. The cœca have become flaccid, and the water has a putrid smell. Dismissed.

No. 2. The two crops have attained their maximum of *turgidity*, but now begin to become flaccid. I opened them, and both their contents were putrid. The mucous membrane is beautifully detached from the other parts.

Observations.—No. 1. Presents us with an example of endosmose continuing for nearly sixty hours, and after this period the inverse action or exosmose has taken place.

No. 2. We observe in this experiment also, the same action of endosmose going on and arriving at an astonishing degree of turgidity, and then the opposite action, *exosmose*, to occur.

No. 3. We observe in this experiment a contrary action to happen, that is *exosmose*, the denser liquid being without and the rarer within the organic tissue. This action has been very rapid, even beyond all expectation.

No. 4. This experiment is no less astonishing. This tendency of the surrounding liquid to permeate the tissues and penetrate into an

organ, even when there is no liquid at all, has been an object of speculation with Dr. Dutrochet.*

Experiments—Second Series.

July 28th, 4 P. M.—Fahr. 77°.—I killed a young rat at two o'clock, and the skin being stripped from the animal's back, I put some pure water in it, and closed it up firmly, the skin being in its natural relative situation. When thus filled with water it weighed 500 grs. It was immersed in a solution of gum arabic, ℥j. water, ℥v.

July 29th, 7 P. M.—Fahr. 74°.—Weighed the rat's skin and contents, and found that it had lost 72 grs. I again replaced it in the same solution.

July 30th, 7 A. M.—Fahr. 72°.—Weighed the rat's skin, and found that since last evening it has lost 24 grs. more, which, added to the 72 grs. lost the previous day, make 96, being nearly a fifth of its weight, and one-third of the water which it contained.

July 31st.—Fahr. 80°.—The rat's skin smells putrid. It was kept constantly in the same solution, which was wrong, because the mucilaginous qualities of the solution changed much.

August 1st, A. M.—Fahr. 80°.—Weighed this morning the rat's skin, and found to weigh 500 grs. The water within being putrid, a partial endosmose has been produced instead of exosmose.

Observations.—This experiment shows very forcibly the power of this action, as it occurred through the very thick skin of a rat.

Experiments—Third Series.†

August 16th, 9 P. M.—Fahr. 74°.—No. 1. A crop containing gum arabic solution with ligatures applied to its natural orifices, and weighing 500 grs. was put in a vessel full of river water.

No. 2. A cœcum containing gum arabic solution, with its orifice tied, and weighing 154 grs. was put in a separate vessel in pure water.

No. 3. A cœcum containing gum arabic solution, and weighing 105 grs. was also put in water.

No. 4. A cœcum containing water, its orifice firmly tied, and weighing 87 grs. was put in gum arabic solution.

No. 5. A cœcum containing gum arabic solution, and weighing 140 grs. was immersed in water in a separate vessel.

August 17th, 8 A. M.‡—Fahr. 74°.—No. 1. Weighs 552 grs. It has increased, in the space of 12 hours, 52 grs.

No. 2. Weighs 269 grs. It has gained 115 grs. in the space of 12 hours, having produced, as well as the preceding experiment, a considerable endosmose.

No. 3. Weighs 157 grs. and has of course augmented 52 grs. in 12 hours.

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* Dr. Samuel Jackson witnessed all the above experiments.

† The object of this series was to repeat some of the preceding experiments.

‡ The water in which the cœca were immersed has been renewed this morning.

No. 4. Weighs 66 grs. There is a loss of 21 grs.

No. 5. Weighs 261 grs. There is an increase of 121 grs.

August 17th, 5 P. M.—Fahr. 75°.—No. 1. Weighs 574 grs. There is still a gain of 24 grs. more in the space of 9 hours. This crop is now very turgid, having taken 44 hours, or thereabouts, to produce this very considerable degree of *turgescence*.

No. 2. Weighs 275 grs. There is an increase of 6 grs. in 9 hours.

No. 3. Weighs 152 grs. having lost 5 grs.

No. 4. Weighs 54 grs. There is a loss of 12 grs. more, and the cœcum is now quite *empty*.

No. 5. Weighs 284 grs. The endosmose still continues, for in the space of 9 hours there has been an increase of 23 grs. and the cœcum is now very *turgid*.

August 18th, 5 P. M.*—Fahr. 74°.—No. 1. Weighs 714 grs. There is an increase of 140 grs. more, in the space of 24 hours.

No. 2. Weighs 277 grs. There is an augmentation of 2 grs. This cœcum has obtained its maximum of *turgidity*.

No. 3. Weighs 151 grs. There is already exosmose, the endosmose having ceased.

No. 4. This cœcum is now entirely empty. I opened it, and found it perfectly sound, the ligature being very firm. This experiment has established exosmose beyond all matter of doubt.

No. 5. Weighs 299 grs. There is a gain of 15 grs. more. Since the beginning of this experiment this cœcum has increased 159 grs. in about 56 hours, being more than one-half of its whole weight; but the liquid has increased at least three times its original quantity. This experiment is a successful and beautiful illustration of *endosmose*. This organ has now attained its maximum of turgidity, and in this state the organ resists a very considerable pressure of the finger without yielding.

August 19th, 10 A. M.—Fahr. 70°.—No. 1. Still increases in size. It weighs 1020 grs. it having increased 306 grs. in 17 hours; and since the beginning of the experiment it has augmented 520 grs. in the space of 72 hours, being now more than double. It is very *turgid*, and has reached its maximum.

No. 2. Weighs 286 grs. There is still an increase of 9 grs. in 17 hours. However, the endosmose is now nearly spent, and hence I dismiss it. The cœcum is very *turgid*, and endosmose very complete.

No. 3. Endosmose has ceased, and exosmose now begins.

No. 5. Weighs 296 grs. Endosmose has now stopped, and the contrary action, exosmose, is going on. Dismissed.

Observations.—No. I. presents a most striking case of endosmose. This action has occurred through the coats of the crop: the mucous, the muscular, and peritoneal coats, which are pretty thick. Had I fixed a tube to one of the orifices of this organ, I have no doubt that endosmose would have continued for some time, and the superfluous

* The crop and cœca were not weighed in the morning, but the water in the vessels was renewed.

liquid would have ascended in the tube, and issued through its orifice.*

Experiments—Fourth Series, with Alkalies and Acids.†

August 22d, 1 P. M.—Fahr. 72°.—No 1. A crop containing some alkaline solution, weighing 426 grs. was put in a separate vessel full of fresh water.

No. 2. A cœcum containing some alkaline solution, and weighing 90 grs. was put in water.

No. 3. A crop containing water, and weighing 463 grs. was put in the alkaline solution.

No. 4. A cœcum containing water, and which weighed 243 grs. was also put in the alkaline solution.

The four following experiments on *acids* were begun at four o'clock on the same day as the preceding.

No. 5. A cœcum containing diluted sulphuric acid, and weighing 148 grs. was immersed in water.

No. 6. A cœcum containing diluted sulphuric acid, weighing 98 grs. was put in water.

No. 7. A cœcum containing water, and weighing 174 grs. was put in diluted sulphuric acid.

No. 8. A cœcum containing water, and weighing 71 grs. was put in diluted sulphuric acid.

August 22d, 8 P. M.—I weighed the cœca and crops employed in the preceding experiments, and found them as follows:

No. 1. Weighs 672 grs. being a gain of 246 grs. in seven hours.

No. 2. Weighs 144 grs. An increase of 54 grs. in seven hours.

No. 3. Weighs 488 grs. An increase of 25 grs. in seven hours. In this experiment we observe an endosmose, when we ought to have according to Dr. Dutrochet, an exosmose. I cannot account for this anomaly.

No. 4. Weighs 191 grs. There is a loss of 52 grs. producing an exosmose, and this agrees with Dr. Dutrochet, as do the following.

No. 5. Weighs 121 grs. There is a loss of 27 grs. in four hours.

No. 6. Weighs 84 grs. There is a loss of 14 grs. in four hours.

No. 7. Weighs 186 grs. There is a gain of 12 grs in four hours.

No. 8. Weighs 82 grs. There is a gain of 11 grs. in four hours.

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* Gum arabic in solution is a very good substance for the production of these physico-organic actions.

I have repeated the above experiments with milk. They tend to prove the same actions as a solution of gum arabic, but its effect is not so rapid as mucilage.

† The solution employed in the following experiments was in the proportion of carbonate of potash, ℥j., water, ℥xii. The diluted sulphuric acid used, was when applied to the tongue, very slightly pungent.

August 23d, 9 A. M.—No 1. Weighs 758 grs. There is an increase of 86 grs. in thirteen hours.

No. 2. Weighs 131 grs. There is a loss of 13 grs. in the space of thirteen hours. From an endosmose we have now an exosmose, and hence I dismiss it.

No. 3. Weighs 435 grs. There is a loss of 53 grs. producing an exosmose, as ought to have been the case at first, but I know not to what cause to ascribe this discrepancy.

No. 4. Weighs 173 grs. There is a loss of 18 grs. This experiment has produced a perfect exosmose.

No. 5. Weighs 113 grs. There is a loss of 8 grs. in the space of thirteen hours. We have in this experiment a very beautiful exosmose produced by the acid contained within the organ.

No. 6. Weighs 76 grs. There is a loss of 8 grs. in this case as in the preceding experiment, No. 5, we have an exosmose, caused by the acid contained in the organ.

No. 7. Weighs 162 grs. There is a loss of 24 grs. in thirteen hours. The action was at first endosmose, but now has changed, and will of course continue as it always does. Dismissed.

No. 8. Weighs 77 grs. There is a loss of 5 grs. There was during the first four hours of this experiment an evident endosmose, although weak, produced by the acid.

August 24th, 10 A. M.—No 1. Weighs 954 grs. A gain of 196 grs. in thirteen hours. It is now very *turgid*. It has increased, in forty-one hours, 528 grs. of water, which must have permeated the organ; this experiment is satisfactory as to the agency of the alkalies in producing *endosmose*.

No. 3. Weighs 378 grs. being a loss of 57 grs. in thirteen hours, and altogether of 85 grs. in forty-one hours.

No. 4. Weighs 158 grs. a loss of 15 grs. and altogether of 85 grs. in forty-one hours, being about two-thirds of the whole weight of the liquid.

No. 5. Weighs 107 grs. a loss of 5 grs. in thirteen hours, the action is now nearly at an end. There is a loss of 41 grains in forty-one hours.

No. 6. Weighs 71 grs. a loss of 5 grs. The exosmose is nearly exhausted.

Observations.—The general conclusion that we may deduce from the preceding experiments is, that when alkalies are contained in a hollow organ, endosmose is produced, when it is an acid, the reverse action, or exosmose occurs; and vice versa, when placed without the organ, the reverse action takes place.*

Experiments—Fifth Series, on the Acids.

August 23d, 5 P. M.—No. 1. A cœcum containing water and weighing 103 grs. was immersed in diluted sulphuric acid, rather stronger than that used in the preceding experiments.

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* The effects of acids, it should be observed in producing exosmose, was not quite as striking as Dr. Dutrochet's experiments led us to conclude.

No. 2. A cœcum containing diluted sulphuric acid, and weighing 117 grs. was put in water in a separate vessel.

At 9 P. M. I weighed the above cœca and found them:

No. 1. Weighing 110 grs. an increase of 7 grs. in four hours.

No. 2. Weighs 96 grs. a loss of 21 grs. in four hours. This experiment, as well as the preceding, perfectly agrees with Dr Dutrochet's.

August 24th, 10 A. M.—No. 1. Weighs 108, there being a loss of 2 grs. in thirteen hours.

No. 2. Weighs 91 grs. being a loss of 5 grs. in thirteen hours. The exosmose still continues, though feeble.

At 5 P. M. weighed again the above cœca.

No. 1. Weighs 108 grs. No change having occurred in seven hours.

No. 2. Weighs 91 grs. No change has occurred. This appears rather singular, but it must be ascribed to the diluted sulphuric acid being stronger than in the preceding experiments.

August 25th, 9 A. M.—No. 1. Weighs 105 grs. The inverse action still continues. This cœcum was emptied, and a small quantity of solution of carbonate of potash put in, and immediately a slight ebullition occurred, indeed even stronger than in the diluted acid in which it had been immersed. This trial proves to conviction that the action of endosmose had caused the acid to pass into the organ through its tissues.

No. 2. Weighs 91 grs. is quite stationary. This cœcum was also emptied and the liquid which remained within was tested with an alkaline solution, but no acid was detected. The water in which the cœcum had been immersed was also put to the same test, but no acid could be detected; the reason must be, because I have changed this water several times, and the acid which issued into it must thus have been gradually removed.

Observations.—These experiments evidently confirm the correctness of the preceding ones on the acids.

I have repeated these experiments on the acids and alkalies over and over again, in order not to leave on my mind the least room to doubt that I might be mistaken, and I found that they all confirm each other.

I have also performed some experiments on the sulphas ferri, in order to ascertain the effect or agency of the metallic salts in the production of endosmose and exosmose. I have not yet arrived at any certain conclusion with respect to the experiments performed on this salt. I shall not therefore relate them.

If it be asked, "what utility can your experiments have in medicine?" I shall simply answer, that if they establish a truth, it is in all cases an acquisition, a step forward made in the science of life, even should we now not find any immediate application. How many facts have been found useful in their application in practice, which, at first, were thought to have no immediate usefulness in the healing art? But this is not entirely the case with respect to these experiments, as we shall now attempt to show.

1st. Dr. Dutrochet observed that when the spermatic sacs of the snail, which resemble very much a retort, were immersed in water, this fluid would pass into them through the parietes and accumulate in such a quantity as to expel the sperm with violence, while at the same time the surrounding liquid would occupy the bulb of the retort-like vesicle. This action lasted as long as there was any sperm in them. He therefore concluded that in order to produce this physico-organic action, it was necessary that a fluid of a denser consistence should exist within these hollow organs, for no sooner was the sperm forced out of the organ by this *unknown action* than this current ceased.

2d. He imitated this experiment with the cœca of fowls, and came to this conclusion: that it matters not what may be the size of the hollow organ, or of how many membranes its parietes are composed, or what may be their relative situation with respect to each other. In all these cases the *turgid state* was equally produced, and called by Dr. D. *endosmose*. From this it is necessarily inferred that the indispensable condition for the production of this action was, that the organic parietes be disposed into a cavity, or have a globular or vesicular form, in order that the surrounding liquid should be forced within by this power, *endosmose*.

3d. That by Dr. D.'s experiments, as well as mine, it has been demonstrated that the introduction of the rarer liquid into the hollow organ entirely depends upon the nature of the contained fluid being of a greater density than that in which the organ is immersed.

4th. That as long as this contained liquid maintains its integrity of composition, the endosmose occurs; but that as soon as it becomes putrid this action ceases, and a contrary action, called *exosmose*, takes place with great rapidity.

5th. That by inverting the experiments, i. e. when the denser liquid of the two is the surrounding liquid, or is on the outside of the organ, the action is also inverse, and the liquid contained, or the rarer, passes out through the parietes, by the inverse action already called *exosmose*.

6th. That when an alkaline solution is separated from the surrounding fluid, say water, and contained in a hollow organ, there occurs a current which carries the water through the parietes of the said organ and renders it turgid to *excess*, that is, it produces endosmose. If, on the contrary, this organ be filled with water and the surrounding liquid be an alkaline solution, then the inverse action, *exosmose*, occurs.

7th. That the preceding deductions are also applicable to the ef-

fects or agency of the diluted *acids;* with this difference, however, that their action is precisely inverse of that of the alkalies.*

8th. We have already established in proposition 3d, that the *denser* fluid induces the rarer liquid to form a current directed towards the former. The consideration of this fact has induced Dr. D. to suppose it, à priori, to be caused by electricity; it being well established that a difference in the density of two substances is productive of electricity. Moreover, it is also well ascertained that the electric fluid accelerates the transudation and evaporization of liquids. These facts evidently prove that this fluid does act on the molecules of liquids, and communicates to them *impulsion.*

The galvanic fluid seems to possess even a greater influence on the molecules of liquids; this fact is said to be satisfactorily demonstrated by the curious experiments of Mr. Porret, published in the "Annales de Physique et de Chimie." I shall briefly relate his experiment.

He separated a vase into two partitions by means of a bladder, and partly filled one of the partitions with water, and into the other introduced a few drops only; he then placed the positive pole in the partition filled with water, and the negative in the other partition. The water passed through the parietes of the bladder, from the partition in which the positive pole was placed into that in which the negative was; that is to say, from the *zinc*, or *less dense*, to the *copper*, or *more dense*, and in this respect following the same law of density as *endosmose* and *exosmose.* Thus these two actions are identified with the two poles of a *galvanic pile* or *electricity.*

This experiment was slightly modified by Dr. D. and was performed with a cœcum, and he obtained the same result. Wherever the negative pole was placed, either within or without the cœcum, there did the fluid flow through the parietes of this viscus.

I have not yet had the opportunity of repeating this experiment, but from the great accuracy of Dr. Dutrochet, I do not doubt that the thing is as he states it.

9th. Another observation seems to confirm this result, and to establish even a greater similitude between *endosmose* and *electricity.*

We see in propositions 6th and 7th that an alkaline solution is productive of an endosmose, when introduced into a hollow organ; but if an acid be placed therein, then an exosmose is caused. Now, if a salt with an alkaline base be submitted to the action of a galvanic pile, the salt is decomposed, and the alkali is transmitted to the ne-

* These chemical agents were always used so weak or diluted as never to induce any alteration in the organic membranes employed in these experiments.

gative pole and the acid to the positive. But we already know that it is towards the negative pole that the current is directed, and that a similar current is also produced by alkalies; and hence the reason they both produce *endosmose*, and why the positive pole and the acids cause the same effect, *exosmose*.

Thus we do not only see the similarity, but even the identity of action of *endosmose* and the poles of a galvanic pile, and that the impulse given to the liquid is owing to an electric current directed from the positive pole, *(zinc*, or *acid*, or *less dense,)* towards the negative, *(copper*, or *alkali*, or *more dense,)* and finally, it is to this action that the accumulation of liquids in a hollow organ is owing, and soon producing and constituting the *turgid state*. Thus endosmose and exosmose entirely depend upon electricity.

10th. Dr. D. compares the hollow organs which present either of these vital phenomena to Leyden jars, with permeable parietes, their interior being occupied by an electricity in an opposite state to that existing on their exterior, and that since the current of the liquid is always directed to the side negatively electrified, it follows that whenever the interior of these *small Leyden jars* are negatively electrified, endosmose occurs; their exterior, however, being positively electrified; and if these states of electricity be reversed, we shall have exosmose.

I have already remarked that the tissues may be resolved into *vesicles* or *globules*, and that they are in fact made up of an agglomeration of these vesicles. Now every one of these vesicles, in their natural state, are filled with a liquid denser than the surrounding water, they consequently produce endosmose; and they therefore act as so many *Leyden jars*, negatively electrified within, and positively without.

It results from this view of the subject, that the cœcum or crop of a fowl, made perfectly air-tight by ligatures, may be considered a hollow organ, the parietes of which are composed of an infinity of these *Leyden jars*, their interior being negative, and their exterior positive. But according to the laws of electricity, the cœcum or crop may itself be considered as a larger Leyden jar, being in the same state of electricity. Dr. D. farther suggests that if a hollow sphere could be constructed with small agglomerated Leyden jars of glass, being all positive externally, and negative internally; this sphere would itself be a Leyden jar of the same kind. This explains beautifully why an empty cœcum placed in water, permits that fluid to permeate and distend it, and thus produce a slight endosmose; and this action most satisfactorily explains the two cases of sudden dropsy,

mentioned by Dr. CHAPMAN in his clinical lectures; the one a gentleman from Boston, the other from Virginia. Both became dropsical immediately after coming out of a bath; they had previously taken violent exercise; one of them took the warm, the other the cold bath; but the same result happened in both. They were at this time, to all intents and purposes, in the state of a Leyden jar, negative within, and positive without; hence the endosmose, and their dropsy. The same may be said of a swollen drowned body, which has also been made *turgid* by the action of endosmose. My experiment on the skin of a rat, to a certain extent, tends to prove the same position, although it was an exosmose.

11th. That when a cœcum containing a denser liquid is placed in a fluid less dense, this latter passes within that viscus; but there exists at the same time a feebler current from within outwards. This fact is particularly exemplified and demonstrated in one of my experiments on the sulphate of iron, in which the water surrounding the cœcum contained some iron that evidently had oozed out by this feebler action, exosmose, while the cœcum continued to become more and more turgid.

12th. Thus it is demonstrated that there exists simultaneously two currents, endosmose and exosmose, both going on at the same time. Then, when we say that a substance produces endosmose, whenever put into a hollow organ, we mean to say that there exists a weaker current from within outwards, besides the one producing endosmose; so that endosmose and exosmose both exist at the same moment in the same organ, or rather in the vesicles composing each organ. To this simultaneous double action we may ascribe, in organized beings, the movements of *composition* and *decomposition*, or *nutrition; interstitial absorption* and *serous exhalation*, and *external absorption; cutaneous absorption* and exhalation; the irrigation of the secretory organs by the blood, and the respective secretions of these organs, which secretions occur in each vesicle that constitutes *chemical filters;* in a word, all these functions are the result of this double movement or action, *endosmose* and *exosmose*.

It is ascertained that electricity produced by the contact of two heterogeneous substances, gives rise to two electric currents passing in opposite directions. In the preceding experiments we have seen that two heterogeneous liquids nearly in contact, that is, simply separated by an organic membrane, produce also an electricity which is manifested by two opposite currents. A most important fact for the experimental philosopher, resulting from these experiments, is,

the difference of force always attending these electric and opposite currents.

15th. That many of the substances which are daily used as articles of food, such as milk, the albumen, as well as the yelk of eggs, solutions of gelatine, gum-water, water sweetened with sugar, and most extractive principles of vegetables, and even opium, produce *endosmose.* Alcohol at 36° is one of the most powerful agents of endosmose; but when largely diluted with water, on the contrary, it produces exosmose. Now, this perfectly agrees with every days observation and experience. We know that alcohol very much diluted, or given in any preparation into which this article enters in small quantity with water, is an excellent diaphoretic or diuretic, according as it may act, or rather according to the degree of temperature, whilst the immoderate use of ardent spirit, as is often practiced by labouring men in this country, produces inflammations or congestions, or extravasations, or effusions in the brain, lungs, spleen, liver, &c. The former mode of administration producing *exosmose* or diaphoresis; the latter mode, endosmose or congestion; hence the absurdity of the administration of alcohol in immoderate quantity whenever there exists already a congestion, as in typhus or typhoid diseases; and again, we are now able to account why diluted vegetable acids of every description are very beneficial in diarrhœa, and in fevers in which the gastro-intestinal canal is primitively affected, and in which the lesion and the fever, its symptom, are to be located.

Dr. Chapman speaks in a very commendatory manner in his lectures, of the use of acids in some very stubborn cases of diarrhœa. The reason why vegetable acids are useful in these affections is because they produce exosmose.

14th. That a higher temperature augments the intensity of the endosmose; hence, my first series of experiments being performed when the thermometer was much higher than at any time when Dr. Dutrochet performed his, the endosmose in mine was proportionately more active. I may also have used my gum arabic solution rather stronger than Dr. D. which would also cause a more intense endosmose. This fact perfectly agrees with the experiments of M. Becquerel, in which he has proved the elevation of the temperature increased the intensity of the electric current.

One more fact may be adduced in addition to those already cited, in order to prove that endosmose is owing to electricity. When a cœcum is almost filled with the albumen of eggs, and immersed in water, it introduces this liquid into this viscus, and causes it to be-

come turgid. But on opening the cœcum a few hours afterwards, the internal surface is found lined with a pseudo-membrane composed of coagulated albumen. Now, it is well known that the coagulation of albumen is one of the effects produced by the current of a voltaic battery.

15*th*. It has been proved by the experiments of Dr. Dutrochet, that the *life* of *nutrition* of vegetables consists entirely in a movement or action of endosmose and exosmose; but these physico-organic actions acknowledge for their principal cause, electricity; consequently, this agent or power is the principle of the life of nutrition of vegetables. That absorption, exhalation, and secretions, constituting in fact the nutrition and *life* of the vegetable, are all performed through the agency of this principle.

It is pretty generally known, that the justly celebrated Bichat, from a mature consideration of all organized bodies, came to the conclusion that the functions of life may be divided into two classes: the first he called *animal life*, or *functions of relation;* the second, *organic life*, or *functions of nutrition*, or *vegetable life*. This division is thought by many not rigorously exact. It has been especially criticised by Buisson, but not on a just foundation, and by Magendie in several notes of his edition of Bichat's work, "Sur la vie et la mort." Although we agree, to a certain extent, with the views of Magendie, that this division is "more brilliant than solid" in its details, and when we minutely compare all animated beings, it is difficult to say where *animal* life terminates, and vegetable life begins, still we cannot help admiring the vast genius of Bichat in this generalisation. His division is sufficiently exact for our purpose, which is to show that the functions of nutrition in man are performed precisely by the same laws as the functions of nutrition in vegetables. But these laws in vegetables are *endosmose* and *exosmose* or *electricity*. We conclude, from the similarity of these functions in *vegetables* and *animals*, that they are in the latter also induced by the same principles; with this difference, however, that in the apparatus of *nutrition* of vegetables no nervous system has ever been positively demonstrated, while in the apparatus of nutrition of animals we observe a system of nerves peculiar to it, I mean the sympathetic or ganglionic system of nerves.

This system, in the higher orders of animals, unites every organ in close relation and sympathy, and has a superintendence over all the functions and vital actions of the organs.

16th. We have already remarked, that every tissue is formed by

the agglomeration of vesicular bodies, containing substances sometimes liquid, at others viscous and tenacious, and again solid, according to the different tissues into the composition of which these vesicles enter; they are irrigated on all sides by blood flowing in infinitely small vessels, and it is by a kind of infiltration that the blood penetrates into these vesicles, (the seat, as it will be demonstrated, of all functions,) and is therein modified. This vesicular state of the tissues in animals, as well as vegetables, is the indispensable condition of endosmose and exosmose, and we shall see, that they are really possessed of this physico-organic action.

The morbid state of the solids, called inflammation, is a condition familiar to every one. It is, also, well known, that the soft parts in this state become turgid, and that the fluids, either remote, or immediately surrounding, are, by an *unknown cause*, drawn, in great quantity, to the affected part.

Here we are struck with the similarity of this phenomenon with endosmose; the effects of which, as we know, are manifested by the *turgid state*, and produced by a movement of *adfluction*.

The arteries going to a part, thus circumstanced, augment in caliber, in order to conduct, and pour more blood into the tissues of the inflamed part. The veins which come from this part are dilated by the impulsion given to the blood, that this part, at this time, expels in greater abundance, and with more force. We have, then, two forces, the one drawing the fluids to the affected part—or *adfluction;* the other, expelling them with greater force than in the normal state —or *impulsion*. There is no doubt in my mind, that inflammation is a phenomenon of endosmose.

This same phenomenon exists also in a normal state, but in a smaller degree of intensity. It is by this *adfluction* that blood is drawn into the minute capillaries, and it is to this same phenomenon of adfluxion, that is owing, the emptying of the arteries after death, when the heart has ceased to contract, and its impulsion, or *vis à tergo*, is at an end; and then the blood is found accumulated in the veins. This proves that the action of the heart ceases before the vitality of the tissues, (or rather of the component vesicles,) disappears, and explains the progression of the blood in the veins.

It would also seem from this, that the supposed contraction of the capillaries does not exist; though I do not pretend to assert, that there are not several other causes which favour the progression of the venous blood; but I cannot agree, for instance, with Dr. Barry, that it is entirely owing to atmospheric pressure, and to the dilatation of

the chest in respiration. To conclude, circulation is a phenomenon, having several causes for its accomplishment, namely, the contraction of the heart, and the endosmose occurring in the vesicles, by which the capillaries are surrounded, and which endosmose acts on the principle of a *sucking* and *forcing pump*, &c. &c. This action of endosmose in the capillaries, and causing the capillary circulation, is described by some French physiologists, as "a kind of *vital aspiration* or *suction*, which draws the blood into the parenchyma of the organs."

17th. The same reasoning holds good, and is applicable to the progressive movement of the fluids contained in the chyliferous and lymphatic vessels. The lymphatic ganglia, which are every where dispersed on the route of these vessels, might be supposed, by a superficial observer, to hinder the progression of these fluids; on the contrary, far from retarding their progress, they are placed here by nature, to favour, facilitate, and perform this great function; and this is again accomplished by *endosmose.*

18th. Thus endosmose exists in a normal state in the organs of animals, of course inflammation is the *exaggeration* or *exaltation* of this physico-organic action, and has been called by Dr. D. an *hyper-endosmose.* *Erectile turgidity* is owing to the same cause, with this difference, that it happens as a normal action, modified by nervous influence; but which normal action, if it were too often repeated, would become permanent, and produce a congestion.

My observations have already extended to so great a length, that the practical application of this physico-organic action must remain for the present, at least, untouched by me; and I must refer my readers to the last thirty pages of Dr. Dutrochet's work, in which they will find some of the most valuable practical hints on the nature and cure of inflammation, on the modus operandi of medicines and dietetic substances, on the action of general and local blood-letting, &c. These thirty pages are pregnant with many truths, and they ought to be studied by every *medical man.*

Philadelphia, March, 1829.